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A STUDY OF CARBON DIOXIDE GAS RETENTION IN REFRIGERATOR CARS DURING THE COMMERCIAL FREIGHT SHIPMENT OF SWEET CHERRIES

Tests made in cooperation with Wenatchee and Yakima Valley shippers, Great Northern, and Chicago, Burlington and Quincy railroads. June 8 to June 23, 1941

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A study of carbon dioxide gas retention in refrigerator cars during the commercial shipment of sweet cherries.

INTRODUCTION

Results of storage tests with sweet cherries, as reported in U. S. Department of Agriculture Technical Bulletin No. 631, have shown that decay can be reduced and desirable color can be preserved when the fruit is held in concentrations of 15 to 25 percent carbon dioxide at 45° F. In H. T. & S. Office Reports No. 25 and 51 are recorded some results of the use of this gas as a supplement to standard refrigeration in the transportation of sweet cherries in a limited number of special and standard refrigerator cars. In general the results of these transportation tests have shown that carbon dioxide gas can be used to advantage even in present equipment. In test fruit of optimum maturity decay was reduced from 16 or 17 percent in the check cars without gas to approximately 5 percent in those carrying low concentrations and to about 1 percent in cars wherein higher amounts of carbon dioxide were present for longer periods in transit.

During the past 3 seasons a continually increasing tonnage of sweet cherries has been shipped from the Pacific Northwest to Eastern markets under standard refrigeration supplemented with solid carbon dioxide or dry ice. Shippers in general have been following the recommendations of the Department of Agriculture in the use of dry ice but have experienced variable results, probably because of the variability in the gas retentiveness of refrigerator cars.

OBJECT OF THE 1941 STUDIES

At the request of shippers of sweet cherries desiring further information relative to the use of solid carbon dioxide, and in order to more closely evaluate its application to present refrigerator car equipment, a study was made during the season of 1941 of the gas retentiveness of a considerable number of refrigerator cars used for the commercial shipment of sweet cherries.

OUTLINE OF THE STUDY

Through the cooperation of various shippers, it was possible to supervise the loading of dry ice in many carlot shipments of sweet cherries upon which further records could be obtained in transit. A majority of the cars were charged with 800 to 1,000 pounds of solid carbon dioxide in individually packaged 50 to 60 pound cartons placed in a crib on the bracing at the doorway. An additional 50 pounds of naked dry ice was placed directly on the water ice in each bunker of the car and broken in small chunks to facilitate rapid sublimation of the gas. A piece of 1/4 inch copper tubing, extending from the quarterlength position at the floor-rack level to the outside of the car, was inserted at the juncture of the car door and body. Air samples were withdrawn through this tube and analyzed for carbon dioxide with a Hayes gas analyzing apparatus.

The number of test cars involved in this study and their diverse destinations precluded the observation of effects on the fruit in most cases. The records taken therefore were confined to the measurement of the carbon dioxide gas concentration in each car at fixed points enroute. These were: at the point of origin (generally from 2 to 4 hours from loading), at Williston, N. D. (approximately 2.7 days after loading) and at North La Crosse, Wis., after approximately 5 days enroute.

Whenever possible, data were also obtained on the amount of dry ice remaining at destination and also on the fruit temperatures on arrival. This was done through special arrangements with the Chicago Fruit Auction Company for reports on consignments handled by them at Chicago.

No consideration was given to the choice of individual refrigerator cars. The cars used from Wenatchee were those regularly supplied by the Great Northern Ry.; those from Yakima were supplied by the Northern Pacific Ry. Excepting W.F.E. 67637 and 67890, all of the cars were standard 50-foot express refrigerators.

Car loading practice, dry ice application, and gas sampling procedures were standardized as much as practicable under commercial shipping conditions. Therefore the major variable under observation was that of the gas retentiveness of the different cars.

RESULTS OF THE TESTS

CO_2 gas concentration in various cars

Data were obtained in 124 carloads of cherries, 119 of which were shipped from Wenatchee and 5 from Yakima, Wash., during the period from June 8 to June 23 inclusive. Results obtained in this study are summarized in Table 1.

There was exceedingly great variation in the gas tightness of the cars from different lines and also among cars from the same line. The steel Pennsylvania cars were used in greatest number and, with the exception of the three N. R. C. cars from Wenatchee, retained the highest average amount of carbon dioxide enroute. The average gas readings for the G. N., P. F. E., and P. R. R. cars at point of origin were approximately the same. Enroute, however, the G. N. and P. F. E. cars showed a greater loss of carbon dioxide than the P. R. R. cars.

The W. F. E. cars used in these tests were not as gas tight as the P. R. R., G. N., N. R. C., or P. F. E. cars. They were only slightly better, relative to gas tightness, than the cars of the remaining lines listed in table 1, all of which were decidedly unsatisfactory in the matter of gas retention. It is doubtful if the shippers received much benefit from the use of carbon dioxide in this latter group of cars wherein gas leakage was so great. While it is true that most of these cars represented older equipment, they were representative of those provided for the movement of the cherry crop so that shippers had to use them. However, it must be remembered that these cars were designed especially for refrigeration and not for supplemental gas treatment of the lading.

Replenishment enroute

Only a limited number of test shipments were made in which the dry ice was replenished enroute. In these instances they were recharged at St. Paul by adding 100 to 200 pounds of solid CO_2 per car (50 lb. paper-wrapped unbroken cakes to each hatch). Gas readings in transit 10 to 12 hours after recharging showed from 13 to 22 per cent carbon dioxide. At this time approximately three-fourths of each 50 pound cake of dry ice still remained. In past experiments replenishment by the above method was effective for about 24 to 30 hours. For shipments east of Chicago, especially those consisting of weak or slightly over-mature cherries, the carbon dioxide should be replenished enroute.

Dry ice remaining at destination

The amount of dry ice remaining at destination varied considerably with the different cars. In some of the early season shipments with low initial charges of dry ice, in which the insulated cartons were not closely packed together in the bracing crib, most of the dry ice was sublimated enroute. In later shipments carrying 1,000 pounds of dry ice and with paperboard containers packed closely together in the bracing, 100 to 250 pounds of solid CO_2 usually remained when destination was in the Chicago area. In the practical use of dry ice it is necessary to have some remaining at destination, just as it is necessary to have water ice remaining in the bunkers at destination.

Accumulation of CO_2 in cars

Loading was finished in some of the cars several hours before they were moved from the shipping point. In these it was possible to determine the extent to which CO_2 gas accumulated from the sublimation of the dry ice and how well it was retained when the cars were not in motion. These results are presented in Table 2.

The rate of accumulation of CO_2 gas was very rapid; maximum concentrations were usually found from 3 to 6 hours after loading. The accumulation of CO_2 from similar initial charges of dry ice varied greatly in the different cars. The records obtained subsequently on these cars indicated that the extent to which the gas concentration was built up immediately after loading could almost be used as an index to predict a car's gas retention record enroute. Data in table 2 show that the maximum accumulation of CO_2 gas in different cars varied between 5 and 24.5 percent.

Utilization of dry ice in different cherry shipping districts of the Pacific Northwest

In 1938 dry ice was used as an adjunct to standard refrigeration in only a few experimental freight shipments of sweet cherries from the Pacific Northwest. The extent to which this practice was used commercially in 1941 is shown in table 3.

Less than 20 cars of cherries were shipped east from the Wenatchee Valley without dry ice during 1941. From the Yakima area approximately two-thirds of the cherry shipments moving eastward by freight carried solid carbon dioxide.

Manufacturers of solid carbon dioxide in the Pacific Northwest were hard pressed to meet the exceptionally heavy demand for their product during the cherry shipping season without jeopardizing their regular trade. The Liquid Carbonic Pacific Corp. of Seattle supplied most of the dry ice required by the Wenatchee shippers of sweet cherries. The Gas-Ice Corporation, with natural CO_2 wells in Klickitat, Wash., built storage bunkers and carried approximately a 300-ton storage supply of their product to meet the needs of the cherry shippers. This company shipped some 50,000 pounds into the Wenatchee area and supplied all the requirements in other districts.

DISCUSSION AND CONCLUSIONS

In this survey of the commercial use of solid carbon dioxide in the shipment of sweet cherries, studies were made on gas retention in 124 carloads of fruit. Refrigerator cars from 14 different car lines were included. Of this number only about 50 cars were sufficiently gas-tight to hold 8 percent or more of CO_2 for 3 days. For the most effective use of the gas treatment of sweet cherries the concentration should average more than twice this amount. It is not surprising, therefore, that Wenatchee shippers in general were quite disappointed in the gas-tightness of the refrigerator cars at their disposal for the cherry shipping season. It must be concluded from the present study that much of the potential value of the dry ice was lost because of the poor gas retention in the refrigerator cars under test. Despite this, however, the majority of cherry shippers are of the opinion that the CO_2 gas gave beneficial results. This is supported by the tonnage of dry ice used, also by reports of receivers in several eastern markets which indicate that despite much wet weather during harvest and the generally softer fruit which resulted, decay was not as general as had been anticipated. Some shippers are of the opinion that a significant part of the 1941 cherry crop could not have been shipped by freight had not the additional protection from CO_2 gas been available. The assumption that the general use of dry ice was responsible for this reduction in decay is strengthened by the results of some experimental storage studies conducted at the Wenatchee Laboratory under simulated transit conditions. Decay in artificially inoculated cherries was substantially reduced in these tests following treatment with only 5 percent CO_2 gas. In the transportation tests reported in H. T. & S. Office Report No. 51, conducted in 1940, decay was also less in test boxes of fruit in cars with only 4 to 6 percent CO_2 gas than in check cars without dry ice.

During the present season 871 cars of cherries were shipped east by freight from the Pacific Northwest under standard refrigeration supplemented with carbon dioxide. Approximately 712,409 pounds of dry ice at point of origin were used in these shipments. Whether shippers will continue to use CO_2 to the same extent in the future is not at all certain and probably will depend largely upon the condition and price of the fruit and the availability of gas-retentive refrigerator cars.

Table 1. Data on the commercial use of dry ice in refrigerator car shipments of sweet cherries.

Car number	Dry ice: Total initial charge	Dry ice: Added St. Paul	Dry ice: Remaining at destination	Fruit temperature at destination 1/: Top	Fruit temperature at destination 1/: Bottom	Carbon dioxide gas inside of car: Wenatchee	Carbon dioxide gas inside of car: Williston	Carbon dioxide gas inside of car: LaCrosse
	Pounds	Pounds	Pounds	° F.	° F.	Percent	Percent	Percent
G.N. 2096	791	None	25	40	-	18	-	-
" 1918	661	do	-	-	-	14½	6	-
" 2116	700	do	-	43	40	12	8	5
" 1911	704	do	-	41	39	9	7	6
" 2126	966	do	-	-	-	17	9	8
" 1921	987	do	-	-	-	15½	6½	5½
" 2046	964	do	-	-	-	14	7	5
" 2108	988	do	-	48	45	17	10	8½
" 1909	988	do	174	46	42	16	11	9
" 2045	1006	200	-	45	42	11	7	11
" 2088	996	None	-	-	-	11*	7	5
" 2055	992	do	-	-	-	14	9	6
" 2068	935	do	105	45	-	13	4	-
" 2134	972	do	-	43	40	14	11	-
" 2090	952	do	163	47	43	16	8½	-
" 2025	976	do	-	-	-	15	8	-
" 2039	986	do	-	46	42	16	8	7
" 2103	987	do	249	43	36	12	7	5
" 2053	916	do	-	44	41	14	9	-
" 2121	990	do	175	48	41	18	11	6½
					Average	14.3	8.1	6.7
R.E.X. 422	696	do	-	-	-	7½	3	-
" 285	741	do	-	50	44	6½	2	-
" 379	954	do	163	42	37	7	3	-
" 294	1007	do	-	42	39	8½	4	-
" 465	1012	do	137	-	-	12½	5	-
" 329	990	do	34	50	44	7	2	-
" 172	1012	do	-	-	-	12	5	3
" 352	1004	do	-	47	43	8	4	-
" 395	1008	do	164	48	45	9½	3	-
" 367	1083	do	-	49	43	8	3	3
" 380	1026	do	-	47	44	8½	2½	2
" 460	954	do	-	47	43	12	4	4
" 1173	990	do	-	47	43	6	3½	2
					Average	8.7	3.4	2.8
W.F.E. 114	700	do	20	45	-	8	6	-
" 159	754	do	117	45	42	11½	6	-
" 101	772	do	84	45	41	13	9	-
" 143	772	do	-	46	44	12½	8	-
" 157	696	do	-	46	42	10	5	3
" 153	825	do	111	47	40	10	5	-
" 103	975	do	82	44	41	13	6	4
" 197	983	do	87	45	38	10	7	5
" 107	970	do	-	45	38	12	7	4
" 149	962	do	262	46	41	14	6	-
" 122	908	do	-	-	-	16*	6½	-
" 163	987	do	-	46	40	10	4	4
" 192	966	do	201	48	43	14	6	4
" 67637	962	do	-	38	38	10**	5½	4
" 160	962	do	-	47	42	12**	6½	4½
" 67890	962	do	-	33	36	14½**	4	3
" 154	954	do	-	46	41	15	7	-
" 170	970	do	-	-	-	11*	4	-
					Average	12.1	6.0	3.9
P.F.E. 502	727	do	-	-	-	11	8½	-
" 556	738	do	-	48	42	15	5	4
" 611	880	do	-	46	42	12	5½	-
" 521	990	do	-	-	-	16	11	6
" 715	945	do	-	-	-	19½*	7½	5
" 748	991	do	-	-	-	13½	11½	6
" 500	956	do	-	-	-	23	13	-
" 637	988	do	-	48	44	16	9	7½
" 528	952	do	-	-	-	12½	10	7
					Average	15.4	9.0	5.9

1/ As recorded by shipper representatives.
* Loaded 12 to 18 hours earlier.
** Experimental test cars.
*** Yakima shipments.

Car number	Dry ice: Total initial charge	Dry ice: Added St. Paul	Dry ice: Remaining at destination	Fruit temperature at destination: Top	Fruit temperature at destination: Bottom	Carbon dioxide gas inside of car: Wenatchee	Carbon dioxide gas inside of car: Williston	Carbon dioxide gas inside of car: LaCrosse
	Pounds	Pounds	Pounds	° F.	° F.	Percent	Percent	Percent
P.R.R. 2756	707	None	117	42	38	8½	6	3
" 2887	696	do	-	-	-	10	10½	-
" 2885	870	do	230	42	40	9	14½	9
" 2689	770	do	-	-	-	9	7	3
" 2658	907	do	-	42	39	11½	6	-
" 2577	960	do	50	-	-	16½	9	-
" 2691	970	do	150	42	38	11	5½	3
" 2764	970	do	235	45	41	11½	11½	6½
" 2702	990	do	290	42	40	20	9	5
" 2861	1000	do	-	-	-	20	20½	7
" 2803	1000	do	-	41	38	14½	11	7
" 2741	1000	do	-	45	41	9	11	4
" 2631	1000	do	-	44	39	13	12	8
" 2860	1075	do	-	42	39	18	16½	12
" 2754	1075	do	136	46	43	17½	11	9
" 2730	1006	do	-	41	39	18	14½	11
" 2723	978	do	-	-	-	14½	13	8
" 2710	1075	do	-	44	41	15	9	5
" 2616	1017	do	-	43	40	18½	14	9
" 2619	1000	do	-	-	-	13	10	8
" 2634	969	do	-	-	-	10	12	7
" 2678	1000	do	-	42	38	18	13	10½
" 2729	1022	do	-	-	-	19½	14	9
" 2683	990	do	-	43	38	13½	4	-
" 2743	1006	200	-	46	40	22½	14	22
" 2653	1006	200	-	43	39	12	7	13
" 2717	1006	200	-	41	38	11	8½	14
" 2801	972	None	-	-	-	10½	8	6
" 2865	964	do	-	-	-	25 *	12	11
" 2886	964	do	-	-	-	22	15	15
" 2777	990	do	-	45	42	18½	8½	7½
" 2715	940	do	-	42	36	17	12½	11
" 2661	988	do	-	-	-	11½	7	7
" 2806	990	do	-	-	-	14	6	5½
" 2627	950	do	-	44	38	17	7½	5
" 2768	1000	do	-	-	-	11	9	7
					Average	14.7	10.5	8.3
N.R.C. 179	728	do	-	-	-	15	11	-
" 204	969	do	-	45	42	18½	17	8
" 429	976	do	-	44	40	18	13	-
" 742	705	200	-	-	-	- ***	-	11
" 514	608	200	-	-	-	- ***	-	15
" 424	1026	200	-	-	-	- ***	-	14
" 763	600	200	-	-	-	- ***	-	6½
" 768	800	100	-	-	-	- ***	-	5
" 740	900	100	-	-	-	- ***	-	4
					Average	17.1	13.6	9.0
M.P. 3241	722	do	-	48	44	12½	4	-
" 3343	964	do	-	-	-	10½	4	4
" 3264	988	do	134	48	43	14	5½	4½
" 3169	1006	200	289	45	43	11	6	8
" 3341	918	None	116	-	-	12	4½	2
" 3338	1012	do	-	-	-	8	5	2
" 3119	1100	do	-	45	42	13	8	7
					Average	11½	5½	4½
M.K.T. 1275	964	None	-	-	-	12	5	-
" 1289	959	200	-	-	-	9	3½	5
" 1276	1083	None	-	50	44	9	5	4
N.Y.C. 5856	1083	do	-	48	42	10	3	2
" 5880	1006	do	-	-	-	6	3	1
" 5983	990	do	-	-	-	8	3	-
S.L.S.F. 5020	742	do	-	-	-	8	2	-
" 5015	974	do	-	42	39	12	4	3
S.A.L. 3635	692	do	-	48	43	8½	2	2
K.C.S. 1408	974	do	-	45	42	10	4	4
T.&P. 1716	960	do	-	-	-	8	4½	-
U.R.T.X. 3187	1026	do	-	47	45	7	3	-

Table 2. Accumulation and retention of carbon dioxide gas in certain refrigerator cars immediately after being loaded with sweet cherries.

Bracing, Charge[1]	Bunker Charge[2]	Time from Loading	Carbon dioxide gas inside of car	Bracing Charge[1]	Bunker Charge[2]	Time from loading	Carbon dioxide gas inside of car
pounds	pounds	hours	percent	pounds	pounds	hours	percent
851	94	2	15.5	838	112	4	15.5
		4	19.5			5	16.5
		15	17.5			6	17.0
		20	14.0			10	13.5
860	102	4	10.5	860	102	5	12.5
		6	10.0			7	12.5
		8	8.5			9	11.5
		12	7.5			12	11.5
858	106	5	18.0	880	110	6	6.0
		11	24.5			7	6.0
		13	24.5			8	5.5
		16	24.5			12	5.0
796	112	3	16.0	880	110	5	14.0
		5	16.0			6	14.0
		16	10.0			7	13.5
		19	9.0			11	10.0
		21	7.0				

1/ Placed in a crib on the bracing at the doorway in unopened shipping cartons weighing 50 to 60 pounds

2/ Naked cakes placed directly on the water ice in each bunker and broken in 4 to 6 inch pieces.

Table 3. Utilization of dry ice in the freight shipment of sweet cherries from the Pacific Northwest during 1941.

District	No. of Cars	Dry ice used
		pounds
Yakima[1/]	462	334,371
Hood River	42	38,865
The Dalles	6	4,791
Milton	21	14,702
Wenatchee[2/]	340	319,680
Total for Pacific Northwest	871	712,409

1/ The Yakima district in general used 600 to 800 pounds of dry ice per car as an initial charge with several replenishments enroute.

2/ Wenatchee shippers generally used an initial charge of approximately 900 pounds per car with no replenishment enroute.